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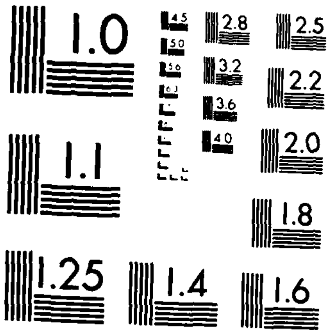

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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PROFESSIONAL PAPER 428 / November 1984

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FORCE LEVELS, READINESS, AND CAPABILITY

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FOREWORD

This presentation outlines a method for examining cost tradeoffs between the number of end items placed at a particular site (force level) and the logistic support provided for the end items. Typically this type of analysis is done on the basis of supporting a specified level of end-item readiness. The method we present discusses the tradeoff in terms of end-item effectiveness in completing the missions for which they are intended.

OBJECTIVE

TO ILLUSTRATE A METHOD FOR EXAMINING TRADEOFFS IN

- FORCE LEVELS (NUMBER OF AIRCRAFT)
- LOGISTIC SUPPORT

ON THE BASIS OF (COMBAT) EFFECTIVENESS

SLIDE 1

My objective today will be to illustrate a method that can be used to examine tradeoffs in force levels (which we will take to be the number of a particular type of aircraft placed at some site) and the logistic support required for these aircraft. The aircraft are assumed to be deployed with the intent of using them in some specific types of missions. The tradeoffs are examined in terms of how successful the force would be in completing these missions.

HISTORY

MANY STUDIES CONCLUDE IT IS BETTER (CHEAPER) TO BUY FEWER UNITS (AIRCRAFT) AND INCREASE SUPPORT FOR REMAINING END ITEMS

- USUALLY DONE ON BASIS OF (CONSTRAINED BY) READINESS
  - MAINTAINING FIXED NUMBER OF AVAILABLE UNITS REGARDLESS OF SIZE OF FORCE
  - DO NOT TIE RESULTS DIRECTLY TO COMBAT/ MISSION EFFECTIVENESS
    - CONSEQUENCES OF ATTRITION NOT ADEQUATELY ANALYZED
    - CAPABILITIES OF END ITEM NOT ADEQUATELY ANALYZED

SLIDE 2

In the past, studies of this type have concluded (under reasonable assumptions about the limits on force levels) that it is often more cost effective to reduce force size and increase logistic support for the remaining forces. However, these conclusions have usually been based on readiness objectives. These studies have failed to consider the real reason for the deployment of these systems and some of the anomalies of combat. In particular, the consequences of attrition have not been considered, and the results of combat which depend on the size of the forces and their capabilities have not been fully analyzed.

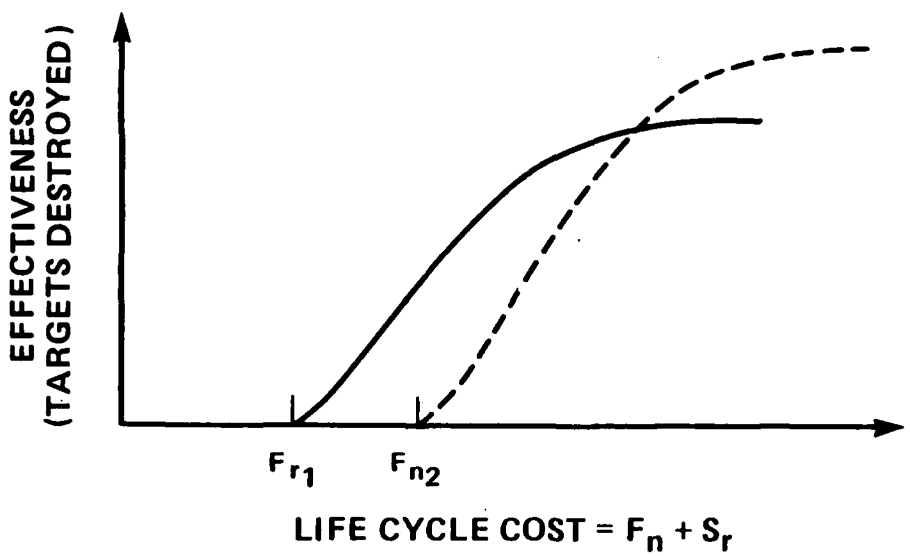
DESCRIPTION OF METHODOLOGY
AIRCRAFT

[1] ESTABLISH UNIT CAPABILITIES
- DETERMINES UNIT COST \$U

[2] ESTABLISH FORCE LEVEL (NUMBER OF DEPLOYED END ITEMS)
- DETERMINES TOTAL FORCE COST \$$F_n$

[3] ESTABLISH READINESS LEVEL — r
- DETERMINES SUPPORT COST \$$S_r$

[4] CARRY OUT MISSIONS (UNDER PLANNED SCENARIOS AND WITH APPROPRIATE THREAT)
- DETERMINES RESULTING EFFECTIVENESS



SLIDE 3

This slide depicts the general considerations in an analysis of the type we have been discussing. First we must determine the capabilities of the systems we are deploying. (In the context of this discussion, capabilities are assumed constant. However, we have used our method not only to analyze various force levels with fixed capabilities but also to analyze the tradeoffs involved with buying more capability for the systems. The capabilities affect the unit cost of the system we are considering. Unit capabilities then determine the costs of procuring this system to meet various force-level objectives.) We then estimate the cost of supporting each force level we are considering to any feasible readiness level. We then carry out the intended mission or missions (through an appropriate simulation of the operations of the systems) for each force level at each readiness level we wish to consider. We then measure the effectiveness of the forces in terms of their intended use. This makes it possible to compare force levels in terms of the relationship between life-cycle costs and a more meaningful measure of effectiveness (such as targets destroyed) than readiness.

MODELING USED TO ESTIMATE LCC-TO-EFFECTIVENESS CURVES

OPERATING HOUR PROGRAM ASSUMED TO BE CONSTANT (INDEPENDENT OF FORCE LEVEL)

- ALL SUPPORT COSTS (OTHER THAN SPARES) HELD CONSTANT
  - MANPOWER
  - TEST EQUIPMENT
  - SUPPORT EQUIPMENT
  - TRANSPORTATION

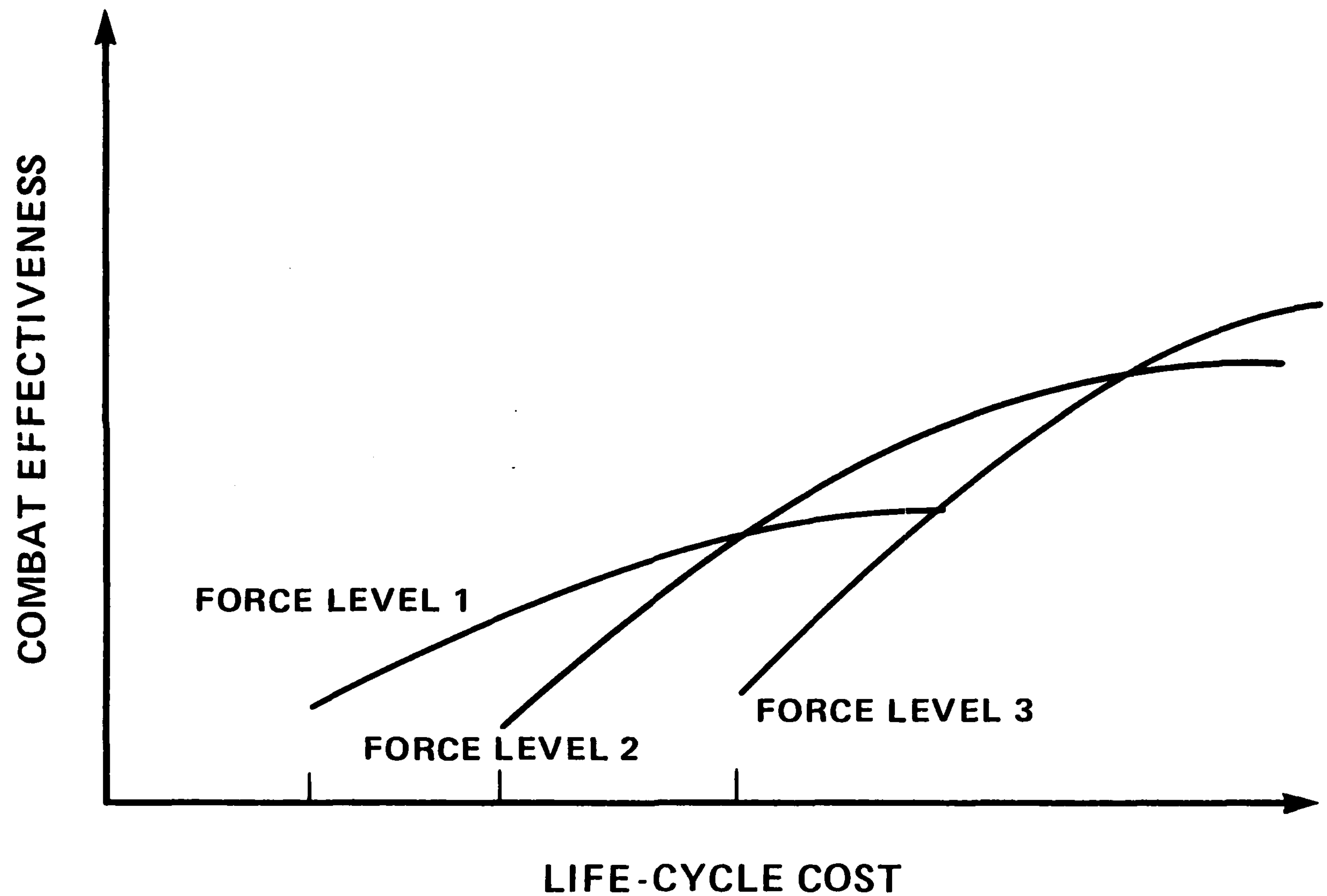
SLIDE 4

All of the above analysis is carried out by executing a sequence of models that can be used to estimate the life-cycle costs (LCC) required to meet readiness levels and estimate the effects of this support in an operational scenario. To estimate the effectiveness of aircraft in a combat role, we used the McDonnell Douglas Campaign II Model which can simulate combat and estimate the results of combat. To predict these results, it uses, as input, unit capabilities (for example, the speed of the aircraft), the number of aircraft available (force levels) at the beginning of hostilities, the readiness of aircraft, a mission plan for the aircraft, and the opposing threat. The important output measures for our purposes are the measures of combat effectiveness, such as targets destroyed, and the attrition of our forces.

SLIDE 11

Finally, we are able to combine readiness-to-effectiveness results (derived from Campaign II) with the MIME/CVSIM results, which equate support costs to readiness. The relationships we wish to examine are illustrated in this slide. Note that a decision to reduce force levels depends on the desired result of combat and the effects of attrition. It is clear from the graph here, for example, that each force level has its limitations in terms of combat results and that there are combat-effectiveness levels at which reducing force levels would not be cost effective.

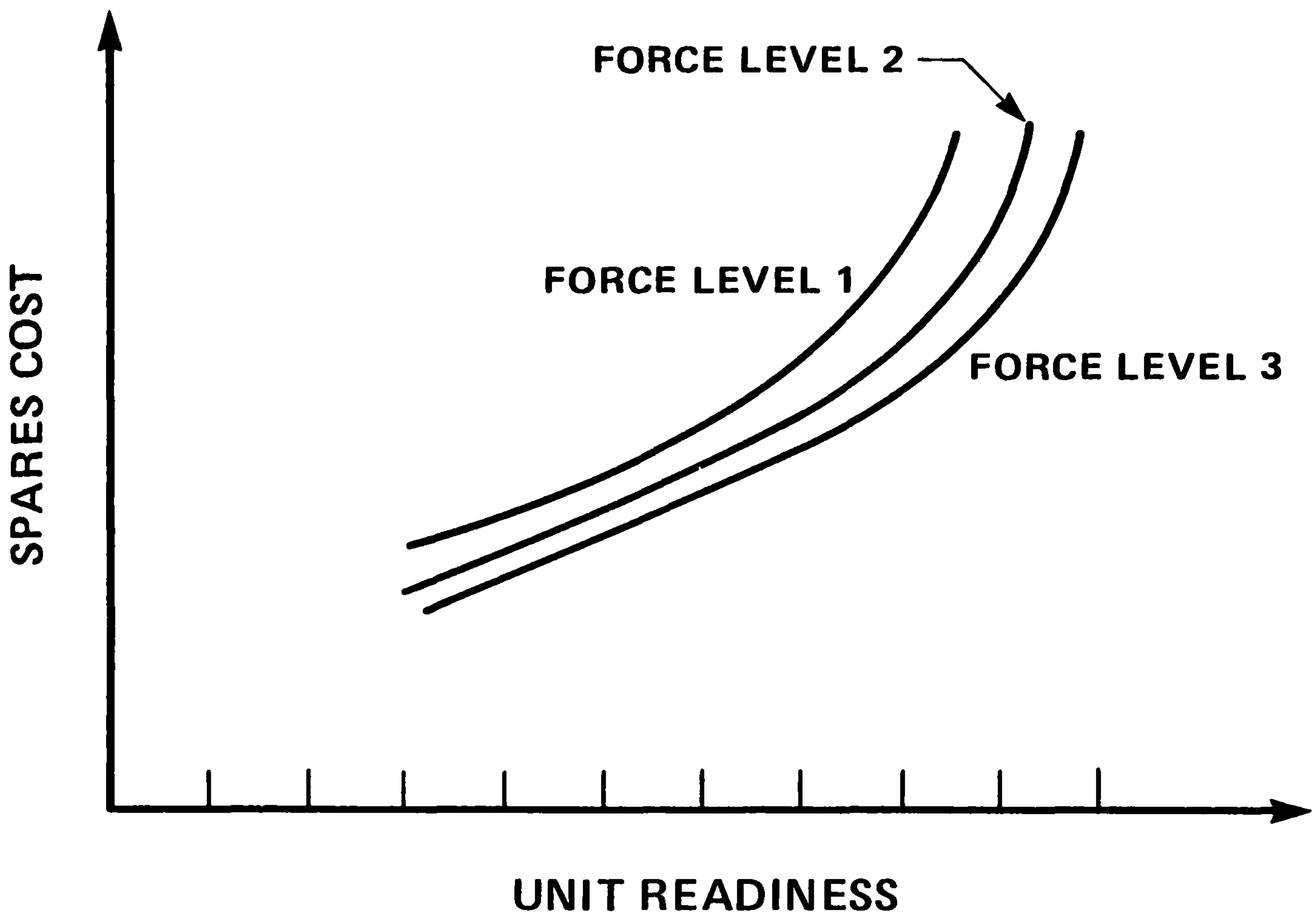
FORCE LEVELS, LIFE-CYCLE COSTS, AND COMBAT EFFECTIVENESS



SLIDE 10

This slide shows the results of using one of the above models to estimate the cost of supporting a readiness level for each of three force levels. Spares costs are again normalized in terms of the unit costs of the systems we are analyzing.

EXAMPLES OF CURVES SHOWING RELATION OF LIFE-CYCLE COSTS TO READINESS



SLIDE 9

To estimate the true readiness produced by MIME sparing, we evaluated the sparing by simulating flight operations using the actual flight program and combat results (in particular attrition) of the Campaign II model. When we found the sparing level that produced the readiness assumed by Campaign II in its analysis, we assumed that the cost of this sparing (logistic support) was the correct one to be associated with the combat results of Campaign II. This process had to be replicated for the alternative force levels and readiness objectives used in our analysis.

These are the three models we considered using in performing this step in the analysis. All the models were capable of estimating aircraft readiness as a function of planned flight operations, attrition, maintenance support, and spare-part support. They could analyze readiness under a cannibalization or a no-cannibalization policy.

EVALUATION OF MIME SPARING TO ESTIMATE AIRCRAFT READINESS FOR OPERATIONS ANALYZED BY CAMPAIGN II

- ESTIMATES READINESS OF AIRCRAFT ON BASIS OF
  - PLANNED FLIGHT OPERATIONS
  - ATTRITION
  - ONBOARD MAINTENANCE
  - OFF-SHIP RESUPPLY
  - SPARES SELECTION
  - CANNIBALIZATION/NO CANNIBALIZATION

POSSIBLE MIME SPARING EVALUATORS

- CASEE — SIMULATION OF CARRIER-BASED OPERATIONS
- CVSIM: SIMULATION OF CARRIER-BASED OPERATIONS
- DYNAMETRIC ANALYTIC MODEL OF CARRIER-BASED OPERATIONS

SLIDE 8

MIME predicts the resulting unit readiness for any collection of spare parts placed at the site in support of the aircraft and is consistent with sparing policy that the Navy will use on an exception basis. But it does not model some of the important factors that affect the operational use of aircraft in a combat situation. The main problems with using MIME's estimates of readiness in the combat model are described on this slide.

PROBLEMS WITH MIME

- CANNIBALIZATION NOT CONSIDERED
- ATTRITION NOT CONSIDERED
- CONSISTENT WITH NAVY SPARING POLICY ON EXCEPTION BASIS ONLY
- DOES NOT MODEL ACTUAL FLIGHT OPERATIONS, QUEUES AT WORK BENCHES, OR CARRIER OPERATION ANOMALIES
- STEADY-STATE MODEL — DOES NOT ANALYZE EFFECT OF SPARING OVER SHORT PERIOD

SLIDE 7

To estimate the life-cycle cost corresponding to a readiness target for a particular force level, we used the MIME (Multi-Item, Multi-Echelon) inventory model. This model was designed at the Center for Naval Analyses to estimate the spare-part cost in meeting a readienss target at minimal cost. This slide shows some of the characteristics of MIME and indicates the mathematical basis for the model.

MODELING USED TO ESTIMATE LCC-TO-EFFECTIVENESS CURVES

ESTIMATING SPARES COST TO MEET READINESS TARGET

- MIME (MULTI-ITEM, MULTI-ECHELON) INVENTORY MODEL
- USED IN SINGLE-ECHELON MODE
  - ASSUMES FIXED LEVEL OF REAR-ECHELON SUPPORT (AS DETERMINED BY RESUPPLY TIMES)
- USES METRIC-TYPE COMPUTATION (M, M, ∞, ∞) QUEUES TO ESTIMATE STOCKROOM AND SITE REPAIR FACILITY EFFECTIVENESS AS FUNCTION OF SPARES STOCKAGE LEVELS
  - ESTIMATES TIME TO REPLACE FAILED PARTS ON END ITEMS
- USES M/M/1/1 QUEUING RESULTS TO ESTIMATE AVAILABILITY A_i OF EACH PART i ON ARBITRARY END ITEM
  - READINESS OF END ITEM = $\prod_{\text{parts}} A_i$
- MINIMIZES SPARES COST SUBJECT TO MEETING UNIT READINESS TARGET

SLIDE 6

In estimating the life-cycle costs associated with supporting the different force levels at various readiness levels, we made the following assumption: the operating tempo of the forces is independent of the force size. This means that, regardless of the number of aircraft we wish to deploy, the total number of flight hours required from these aircraft is held constant. In this way, we plan for the same number of total missions. Because demand for repair and replacement parts is relatively constant under this assumption, the costs of manpower, test equipment, and support equipment are taken to be constant. The cost of meeting a readiness target is then dependent only on the spare parts placed at the site to make timely repairs of the aircraft.

MODELING USED TO ESTIMATE LCC-TO-EFFECTIVENESS CURVES

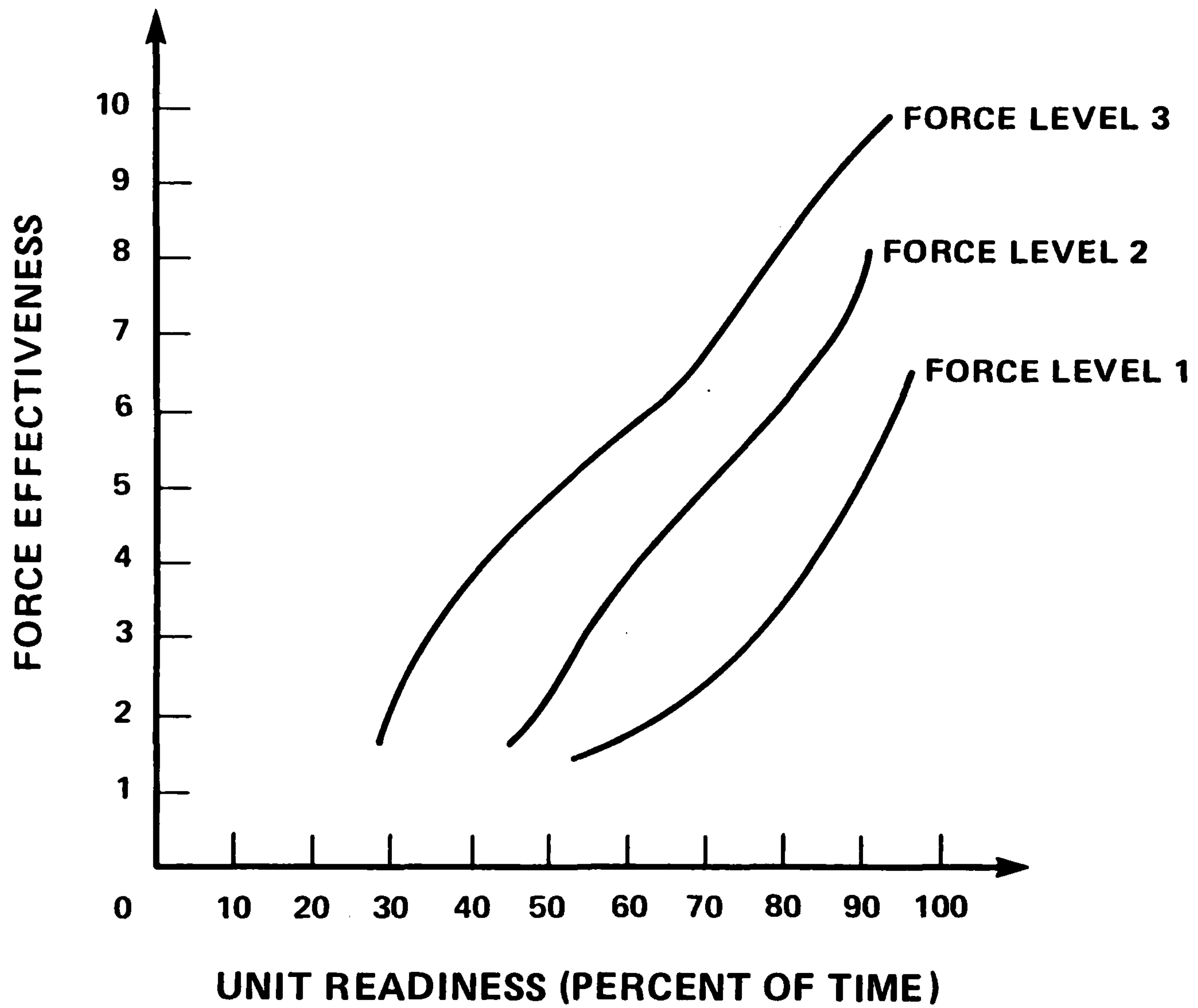
COMBAT MODEL – McDONNELL-DOUGLAS CAMPAIGN II MODEL

- "PSEUDO" SIMULATION OF CARRIER-BASED OPERATIONS
- INPUTS
  - UNIT CAPABILITIES (RANGE, SPEED, ETC.)
  - FORCE LEVELS
  - READINESS
  - MISSION PLAN
  - THREAT
- OUTPUTS
  - MEASURES OF COMBAT EFFECTIVENESS (TARGETS DESTROYED)
  - ATTRITION OF OWN FORCES

SLIDE 5

This slide shows the results of several Campaign II runs. The effectiveness of the forces are normalized for the convenience of presentation, and force levels correspond to different numbers of aircraft at a site.

TYPICAL READINESS-TO-EFFECTIVENESS CURVES GENERATED BY CAMPAIGN II



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2. Listings for Professional Papers issued prior to PP 407 can be found in *Index of Selected Publications (through December 1983)*, March 1984.

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